**I CLAIM:**

1. A method of establishing explicit constrained edge-to-edge paths in a one of an Internet Protocol (IP), MPLS and Optical network that uses a modified open shortest path first (OSPF) routing protocol for constraint route distribution and path computation, comprising steps of:

   a) sending traffic engineering link state advertisement (TE-LSA) messages from OSPF routers in the network to a nearest one of at least one traffic engineering route exchange router (TE-X) in the network, to permit each of the at least one TE-X to maintain a traffic engineering link-state database (TE-LSDB); and

   b) querying the nearest one of the at least one TE-X to obtain an explicit edge-to-edge path satisfying specified traffic engineering (TE) constraints.

2. The method as claimed in claim 1 wherein the step of querying is performed by the first edge router in the network.

3. The method as claimed in claim 1 wherein the step of sending is performed by sending the TE-LSAs directly from the OSPF routers to the nearest one of the at least one TE-X, without flooding the TE-LSAs to other routers in the network.

4. The method as claimed in claim 1 further comprising a step of discovering the nearest one of the at least one TE-X via normal OSPF Router Link-State Advertisement messages.

5. The method as claimed in claim 4 further comprising a step of compiling and storing a list of all TE-Xs in a routing area and using the list to select a nearest TE-X based on a route cost factor associated with a shortest path route to respective TE-Xs in the list.

6. A method as claimed in claim 1 further comprising a step of discovering peer TE-Xs in the network by learning at each TE-X of other TE-Xs using normal OSPF Router Link-State Advertisement messages (Router LSAs), and storing a list of other TE-Xs discovered in the network.

7. A method as claimed in claim 6 further comprising a step of sending one of a Hello and Keep-Alive message to each other TE-X discovered in the network.

8. The method as claimed in claim 7 further comprising a step of sending traffic engineering link states from each of the at least one TE-X to each other TE-X discovered in the network, in order to synchronize the TE-LSDBs.

9. The method as claimed in claim 1 wherein each of the at least one TE-X advertises its capability as a TE-X

using a TE-bit in an Options field of Router Link-State Advertisement (Router LSA) messages.

10. The method as claimed in claim 1 further comprising a step of sending resource reserved (RR) TE-LSAs from the TE-X to peer TE-Xs in the network to advise the peer TE-Xs of resources reserved when an explicit constrained path is established.

11. The method as claimed in claim 10 further comprising a step of sending a release explicit route message from an OSPF router that requested an explicit constrained path to the nearest TE-X, after the explicit constrained path is released, to permit the TE-X to flush RR TE-LSAs related to the explicit constrained path that was released.

12. The method as claimed in claim 11 further comprising a step of sending resource reserved (RR) TE-LSAs from the TE-X to peer TE-Xs in the network to permit the peer TE-Xs to flush the RR TE-LSAs related to the explicit constrained path that was released.

13. The method as claimed in claim 1 wherein the TE-LSAs include type, length, value (TLV) fields to define router addresses and link states.

14. The method as claimed in claim 13 wherein the TE-LSAs further include sub-TLV fields.

15. The method as claimed in claim 14 wherein the sub-TLV is a VPN sub-TLV used to indicate to other nodes in the network the VPN Identifier (VPN ID) that is associated with a router.

16. The method as claimed in claim 14 wherein the sub-TLV is a Replicating Capable sub-TLV used to indicate to other nodes that a router is capable of replicating data to more than one end point.

17. A traffic engineering route exchange router (TE-X) in a network that uses an open shortest path first (OSPF) routing protocol, comprising:

a) a traffic engineering link-state data base (TE-LSDB) compiled using traffic engineering link-state advertisement (TE-LSA) messages received from OSPF routers in the network; and

b) a messaging system for exchanging TE-LSA messages with peer TE-Xs in the network.

18. The TE-X as claimed in claim 17 wherein the TE-X is an area border router (ABR).

19. The TE-X as claimed in claim 18 wherein the ABR exchanges summary TE-LSAs with peer TE-Xs in other routing areas to provide information respecting paths across another area, and available resources associated with the paths.

20. The TE-X as claimed in claim 17 wherein on initialization the TE-X advertises its presence in

the network using router link-state advertisement (Router LSA) messages.

21. The TE-X as claimed in claim 17wherein a TE-bit is set in the Router LSA messages to advertise to other routers in the network that the TE-X has traffic engineering route exchange capability.

22. The TE-X as claimed in claim 17 wherein the TE-X discovers peer TE-Xs in the network.

23. The TE-X as claimed in claim 22 wherein the discovers peer TE-Xs in the network by exchanging normal OSPF routing information with other routers in the network and creating adjacencies with neighbors in the network.

24. The TE-X as claimed in claim 23 wherein the TE-X further derives and stores a list of peer TE-Xs in the network using a downloaded domain link-state database.

25. The TE-X as claimed in claim 24 wherein the TE-X further sends one of hello and keep-alive messages to the other TE-Xs in the list in order to discover a designated TE-X and a backup designated TE-X in the network.

26. A TE-X as claimed in claim 25 wherein the TE-X exchanges TE-LSA messages with the designated TE-X after peering with the designated TE-X, to obtain all

current TE-LSAs for the network, and stores the TE-LSAs in the TE-LSDB.

27. A TE-X as claimed in claim 26 wherein the TE-X flushes from the TE-LSDB obsolete TE-LSAs when more current TE-LSAs are received from an OSPF router in the network, which originated the TE-LSA.

28. A TE-X as claimed in claim 17 wherein the TE-X:

a) accepts queries from a first OSPF edge router for an explicit route between the first OSPF edge router and a second OSPF edge router in the network;

b) computes the explicit route using information stored in the TE-LSDB; and

c) sends information relating to the explicit route to the first OSPF edge router.

29. A TE-X as claimed in claim 27 wherein the TE-X updates the TE-LSDB when the information respecting the explicit route is sent to the first OSPF router.

30. A method of reducing traffic engineering messaging loads in an OSPF network, comprising steps of:

a) configuring at least one OSPF router in the OSPF network as a traffic engineering route exchange router (TE-X);

b) enabling the at least one TE-X to advertise to other OSPF routers in the network to permit the other OSPF routers to distribute traffic



A1

engineering link-state advertisement (TE-LSA) messages to at least one TE-X; and

c) enabling the other OSPF routers in the network to send the TE-LSA messages directly to a nearest one of the at least one TE-X, and to query the nearest one of the at least one TE-X for an explicit route to an edge router in the network.

31. The method as claimed in claim 30 further comprising a step of enabling the at least one TE-X to build a traffic engineering link-state database (TE-LSDB) using the at least one TE-LSA messages, and further enabling the TE-X to use the TE-LSDB for computing the explicit route.

32. The method as claimed in claim 31 further comprising a step of enabling the at least one TE-X to send copies of the TE-LSA messages directly to peer TE-Xs in the OSPF network, and to receive TE-LSA messages directly from peer TE-Xs in the OSPF network.

33. The method as claimed in claim 32 further comprising a step of enabling the at least one TE-X to flush outdated TE-LSAs from the TE-LSDB when a more current TE-LSA is received.

34. The method as claimed in claim 30 further comprising steps of:

a) enabling the other OSPF routers in the network to compile a list of the at least one TE-X in the network using network routing information;

b) to select the nearest TE-X based on a least cost route of respective routes to respective ones of the at least one TE-X.

35. The method as claimed in claim 34 further comprising a step of enabling the other OSPF routers in the network to select a nearest TE-X by sending a probe message to the at least one TE-X in an order of least cost route until a one of the at least one TE-X acknowledges the probe message, thereby accepting to serve as nearest TE-X to the other OSPF router sending the probe message.

36. The method as claimed in claim 35 further comprising a step of enabling the other OSPF routers in the network to select a backup TE-X by sending a probe message TE-Xs remaining after selecting the nearest TE-X in an order of least cost route until a one of the remaining TE-Xs acknowledges the probe message, thereby accepting to serve as backup TE-X to the other OSPF router sending the probe message.

37. The method as claimed in claim 30 further comprising a step of enabling the at least one TE-X to advertise to other OSPF routers in the network using a TE-bit in an Option field of an OSPF Router LSA message.

38. A data network that uses an open shortest path first (OSPF) routing protocol, comprising:

a) a plurality of OSPF routers, at least one of the OSPF routers being adapted to function as a traffic engineering route exchange router (TE-X); and

b) a remainder of the routers being adapted to send traffic engineering link-state advertisement (TE-LSA) messages directly to a one on the at least one TE-X, to enable the TE-X to maintain a traffic engineering link-state database (TE-LSDB) for computing explicit routes between edge routers in the data network.

39. A data network as claimed in claim 38 wherein the at least one TE-X is further adapted to send a copy of each TE-LSA received from the other OSPF routers in the data network directly to each peer TE-X in the data network.

40. A data network as claimed in claim 39 wherein the other routers in the data network query the one of the at least one TE-X to obtain an explicit route to another router in the data network.

41. A data network as claimed in claim 38 wherein the at least one TE-X is an area border router (ABR) in a routing area of the data network.



A1

42. A data network as claimed in claim 38 wherein the at least one TE-X is an autonomous system border router (ASBR) in a an autonomous system of the data network.

43. A data network as claimed in claim 41 wherein the ABR peers with TE-Xs in other routing areas of the data network to which the ABR is connected.

44. A data network as claimed in claim 42 wherein the ASBR peers with TE-Xs in other autonomous systems and other routing areas of the data network to which the ASBR is connected.

45. A data network as claimed in claim 29 wherein the data network is one of an Internet Protocol (IP), Multi-protocol Label Switched (MPLS), and Optical network.



#1